Setting Numerical Population Objectives for Priority Landbird Species[1]

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Abstract

Following the example of the North American Waterfowl Management Plan, deriving numerical population estimates and conservation targets for priority landbird species is considered a desirable, if not necessary, element of the Partners in Flight planning process. Methodology for deriving such estimates remains in its infancy, however, and the use of numerical population targets remains controversial within the conservation and academic communities. By allowing a set of simple assumptions regarding species' detectability, relative abundance data from Breeding Bird Survey (BBS) routes may be extrapolated to derive first approximations of current, total species populations, both rangewide and within Bird Conservation Regions. Preliminary comparisons with independently derived abundance estimates (e.g., Breeding Bird Atlas) suggest that these population estimates are within acceptable limits of accuracy for many species. If restoring populations to early BBS levels (late 1960s) is desirable, trend data may be used to calculate the proportion of a species' population lost during this 35-year period, and an appropriate population target may be set. For example, in the Lower Great lakes/St. Lawrence Plain, BBS data indicate a current (1990-1999) population of about 14,000 Red-headed Woodpeckers (*Melanerpes erythrocephalus*) and a loss of >50 percent since 1966. A reasonable conservation objective, therefore, may be to double the Red-headed Woodpecker population in this region over some future time period. We encourage the use of numerical population estimates and conservation targets in implementing conservation objectives for priority landbird species, and we encourage further research that leads to refinement of our methodology and our estimates.

Key Words: Breeding Bird Survey, landbirds, population estimates, population objectives.

Introduction

Conservation actions are most effective and efficient when they are directed towards meeting explicit objectives or targets. In North America, conservation of birds and their habitats has benefited from numerical population targets developed by regional or species experts. For waterfowl and wetland habitats in particular, species-specific population targets were developed and published as part of the North American Waterfowl Management Plan (NAWMP 1986). Population targets were based on estimates from survey data from the 1970s, and these served as a baseline for restoring populations of declining species. These numerical targets, when scaled to waterfowl flyways and expressed in terms of habitat-acres or other limiting factors, have proven to be a very compelling tool for generating billions of dollars for wetland protection and restoration (NAWMP 2003). More recently, the U.S. Shorebird Conservation Plan has set numerical population targets for priority shorebird species, based on current survey data and also using early 1970s as a baseline (Brown et al. 2001). Other examples of numerical population targets exist in the numerous recovery plans for endangered species in the United States and Canada.

Conservation planning for the roughly 500 species of non-endangered landbirds in North America has been proceeding at the regional and national levels through the international initiative, Partners in Flight (Pashley et al. 2000). Although much discussion has taken place regarding the desirability and possible nature of population objectives for landbird species, we are just beginning to develop methods for deriving quantitative population targets for widespread and still-numerous species. Such numerical targets require the estimation of species' population size at several geographic scales, knowledge of recent historic population trends, and agreement on time-frames and baselines for setting desirable targets. In this paper we outline a pragmatic and repeatable approach to estimating landbird population sizes using indices from the North American Breeding Bird Survey (BBS, Robbins et al. 1989), the most comprehensive and continuous survey of landbird populations in most of the United States and southern Canada. We also discuss the many assumptions and issues that bear on the use of this approach. In addition, we propose a simple protocol for assigning numerical conservation targets for specific regions, based on current population estimates for high-priority species and knowledge of recent population trends. We present preliminary results of population estimation and objective

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setting for two Bird Conservation Regions (BCRs) in which active bird-conservation initiatives are underway, the Atlantic Northern Forest (BCR 14) and Lower Great Lakes-St. Lawrence Plain (BCR 13). Finally, within these two regions, we compare our BBS-derived population estimates with independent estimates derived from alternative datasets. Additional details and results of our population estimation methods are found in the PIF North American Landbird Conservation Plan (Rich et al. 2004). Our goal here is to introduce a standardized methodology for incorporating numerical population objectives into landbird conservation plans and to stimulate further refinements of the population estimation approach.

Methods and Assumptions

Our primary method for estimating population size of widespread landbird species involves extrapolation using indices from the North American Breeding Bird Survey. Specifically, indices of relative abundance (birds per BBS route) were derived from every route surveyed during the 1990s. Relative abundance indices for each bird species were then averaged across all routes within each Bird Conservation Region. By making a series of assumptions regarding area sampled, habitats sampled, and detectability of individual bird species, we can extrapolate BBS' relative abundance to estimate total population size within geographic areas or for the entire continent.

Estimating Population Size from BBS Relative Abundance

A BBS route consists of a series of 50 point counts, distributed along a 39.4 km (24.5 mile) roadside tran--sect. The starting point and direction of each route are assigned randomly within 1-degree blocks of latitude and longitude in the United States and Canada (Robbins et al. 1989). Each route traverses a variety of habitat types; taken together, the routes in a region potentially provide a random sample of the broad landscape within that region as a whole. At each of the 50 BBS stops on a route, observers are instructed to count all birds seen or heard within a 3-minute period, out to a radial distance of 400 m (1/4 mile). The maximum area sampled by each route, without making any corrections for species' detectability (see below), is roughly 25.1 km^2 (*fig. 1*).

A formula for estimating regional population density from BBS counts has been presented by Bart (in press). This formula explicitly takes into account the proportion of individual birds that sing (or otherwise are detectable) during the 3-minute BBS stop, the probability that a singing bird will be detected by an observer, and the potential bias due to differences in roadside and region-wide distribution of habitats. An advantage of this formal approach is the ability to calculate error associated with population estimates, and values of 1.0 can be used for probability terms that cannot yet be estimated with empirical data. Bart (in press) provides examples of this approach for a suite of species in shrub-steppe habitats in the western United States.
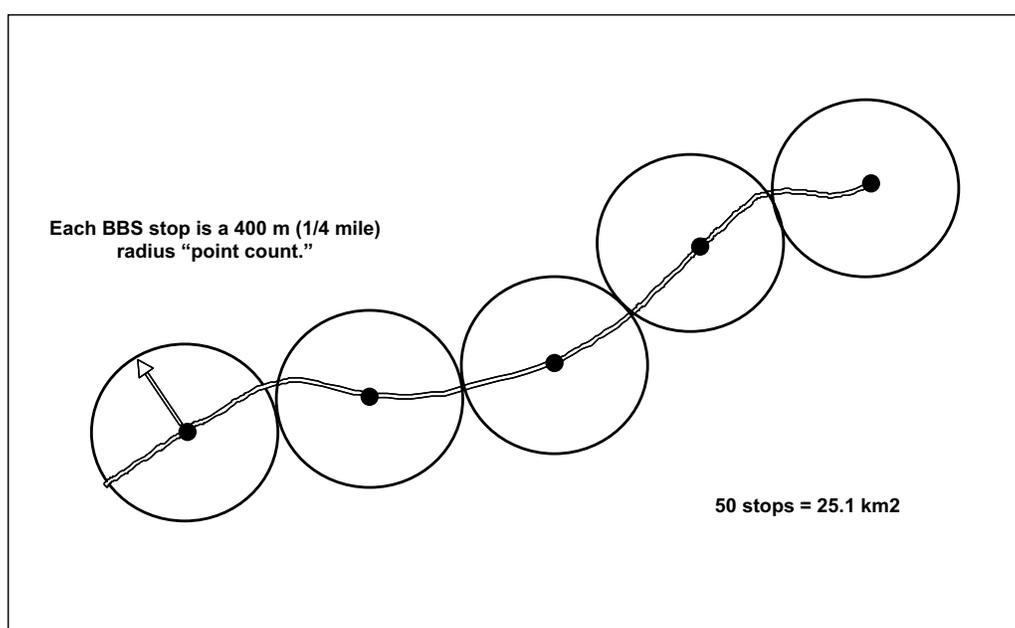

Each BBS stop is a 400 m (1/4 mile) radius "point count."

50 stops = 25.1 km2

Figure 1— Schematic of a BBS route, illustrating how the 50 roadside points, each sampling out to a distance of 400 m, can sample a maximum of 25.1 km^2.

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Assumptions: Habitats

For the purpose of our initial analyses, we assume that (1) BBS routes are randomly distributed across larger landscapes (e.g., BCRs), and (2) BBS routes sample habitats in proportion to their occurrence within the larger landscapes. Because BBS routes are assigned at randomly located starting points, and because BBS coverage is widespread across most of the United States and southern Canada, our first assumption is probably reasonable for most of the BBS coverage area. An exception occurs in boreal and arctic BCRs at the northern limit of BBS coverage, where roadless areas predominate and roads typically sample a geographically biased portion of the landscape.

The second assumption, namely that habitats along roadsides are an adequate sample of habitats throughout the region, is frequently discussed and is considered by some to be a serious flaw of the BBS. Although the capability now exists to test this assumption using GIS, this analysis has not yet been carried out for the entire survey area, or for many local regions. Those few studies that have examined potential roadside bias have presented mixed results. For example, Bart et al. (1995) found that the proportion of forest along BBS routes in Ohio (in a strip out to 280 m from roads) was not significantly different from the proportion in the overall landscape. In an inner strip within 140 m, however, the proportion of forest was significantly less (35 percent) than in the overall landscape, suggesting that for forest-breeding species detected primarily close to roads (see below), BBS would underestimate abundance. Keller and Scallan (1999) found similar results in Ohio and Maryland, with forest habitats under-sampled by 21 to 48 percent and agricultural and urban habitats over-represented along roads. Interestingly, forest-field edge habitats also were under-sampled along BBS routes, whereas early successional and wetland habitats did not differ between on-road and off-road landscapes. Most recently, Bart (in press) found that proportions of major forest, shrub-steppe, and grassland habitats along BBS routes did not differ from the surrounding landscape within U.S. Forest Service Region-4, a large area of the western United States. While we urge a continent-wide GIS analysis of roadside bias in the BBS, which could yield BCR-specific correction factors to plug into Bart's equation, for now we assume no roadside bias in our calculations. Further ramifications of this assumption will be discussed below.

Assumptions: Species Detectability

Our initial approach assumes that all breeding pairs of birds very close to an observer at BBS stops are detected, and that detectability is otherwise a function of distance from the observer. We assume that all species have a fixed, average maximum detection distance on BBS routes across their range, and that these distances can be translated into effective sample areas for each species. Because few published data exist on exact detection distances for a wide range of species, we chose to assign species to one of four detection classes as follows (*table 1*). A majority of birds on BBS routes in many regions are detected by songs or calls in forested or other densely vegetated habitats. A simple method of extrapolating avian density from counts of singing males using detection threshold distances was proposed by Emlen and De-Jong (1981), who also provided average maximum detection distances for 11 species of common forest birds. These distances ranged from 72 m (Blue-gray Gnatcatcher [*Polioptila caerulea*]) to 186 m (Wood Thrush [*Hylocichla mustelina*]) and averaged 128 m for the 11 species. Emlen and DeJong (1981) further proposed that numbers of singing males be doubled to obtain a total population. Wolf et al. (1995) also found that most forest birds in northern Wisconsin could be heard to maximum distances of between 125 and 250 m. There was much individual variation, however, and some individuals could be heard at much greater distances. Wolf et al. (1995) also recorded the minimum distance at which individuals of a species could no longer be heard; this distance also averaged 128 m for the 12 species presented. Based on these empirical data, we chose to initially assign most forest birds and other weakly vocalizing species a detectability threshold of 125 m (close to the average in Emlen and DeJong's study). For these species, we assume that all breeding pairs are detected out to that distance, and the effective area sampled on a complete BBS route is therefore 2.5 km^2.

Table 1— *Categories of detection distances and equivalent BBS sampling area for landbirds.*

Maximum detection distance (m)	Effective BBS sample area/route (km^2)	Example species
80	1.0	Brown Creeper, Blue-gray Gnatcatcher, Golden-crowned Kinglet, Ruffed Grouse
125	2.5	Most forest-breeding warblers, Red-eyed Vireo, Downy Woodpecker, accipiters
200	6.3	Thrushes, waterthrushes, wood-pewees, meadowlarks, Bobolink, Song Sparrow
400	25.1	Whip-poor-will, Pileated Woopecker, Red-tailed Hawk, crows, vultures

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A second group of species is detected visually or by loud calls over long distances; these include soaring raptors, crows and ravens, Upland Sandpipers (*Bartramia longicauda*), and a few other species with very loud vocalizations (e.g., Northern Bobwhite [*Colinus virginianus*], Pileated Woodpecker [*Dryocopus pileatus*]). For these species, we assume that all breeding pairs are detectable out to the full range of sampling at each BBS stop (i.e., 400 m). The effective sampling area is therefore the same as for the total BBS route, i.e., 25.1 km². A third group of species is considered to be intermediate and was assigned a detection distance of 200 m (effective sampling area = 6.3 km²). These include species such as Bobolink (*Dolichonyx oryzivorus*) and kingbirds (*Tyrannus* spp.) that are detected by a combination of song and visual observations in open habitats.

After initially assigning most forest birds to the 125-m detection threshold category, we made two additional adjustments. First, for species with especially weak vocalizations, such as those with the closest detection thresholds in the above studies (e.g., Blue-gray Gnatcatcher), we created a fourth category with a detection distance of 80 m and an effective sample area for a BBS route of 1.0 km². We assigned a few other species that are particularly difficult to detect, such as grouse, into this category as well. Our second adjustment was to move several groups of forest birds with loud or far-carrying vocalizations into the 200-m threshold category. These included Ovenbird (*Seiurus aurocapillus*), most thrushes, pewees, tanagers, and some vireos. Our final estimate of detection-threshold categories was based on a combination of published data, our own personal experience on BBS routes, and consultation with other experienced observers. In the future it should be possible to use species-specific detection distances for a majority of species, rather than the categories used here.

In addition to correcting for detectability due to distance from the observer, we know that detectability also varies with time of day throughout a typical BBS route. Although surveys begin before sunrise, during the peak of vocal activity for many species, a full route takes several hours to complete and numbers of birds detected on later stops may be a small fraction of those detected on early stops. To correct for this variation, we examined the distribution of detections among the 50 BBS stops, for 369 species with at least 10 routes of stop-by-stop data across the entire continental BBS survey. Based on these distribution curves (*fig. 2*), we determined the peak detection probability for each species and then the ratio of peak detections to average detections across the 50 stops. This ratio was used to adjust average numbers of birds per route to peak numbers, as if peak detection lasted throughout the morning. Species-specific correction factors ranged from
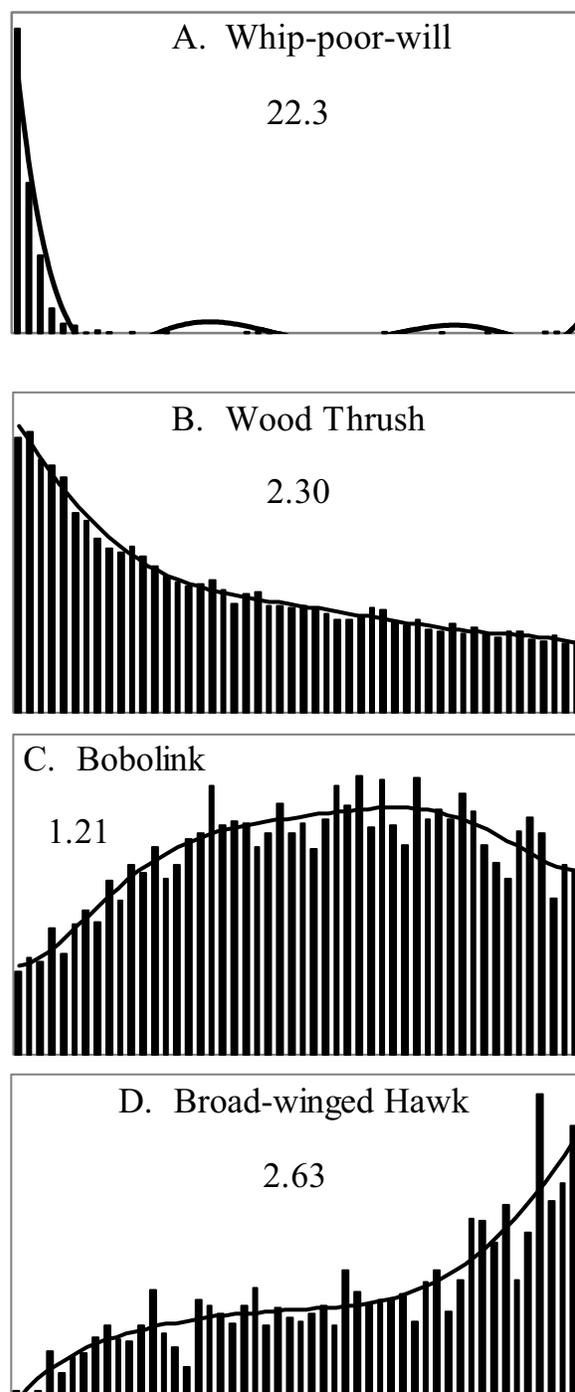

Figure 2— Distribution of detections across 50 BBS stops for four species with contrasting temporal patterns. Lines are 6th order polynomial regressions fit to the data. Numbers are time of day adjustments (max detection / avg detection) used in population estimates.

1.04 (House Finch [*Carpodacus mexicanus*]) to 22.3 (Whip-poor-will [*Caprimulgus vociferus*]) with a median of 1.34 across all landbird species examined (median of 1.32 for diurnal landbirds). Four different types of time-of-day distributions are illustrated in *figure 2*. Using these corrections, we can estimate populations

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even for crepuscular or primarily nocturnal species (e.g., Great Horned Owl [*Bubo virginianus*], Common Nighthawk [*Chordeiles minor*]), as long as they are detected on several BBS routes on at least the first BBS stop. For the few species without adequate BBS data to calculate a time-of-day correction, we assigned a value based on another similar species with adequate data, or used the median value. Our time-of-day corrections will tend to be conservative for any species whose peak detection is outside of the BBS sample period, diurnally or seasonally.

Finally, we assume that individuals detected represent one member of a pair, and we therefore double all estimates to derive total number of breeding individuals. This 'pair correction' is most obvious for the many species that are primarily detected as territorial singing males. Even for species in which males and females may be equally detectable, however, our experience on BBS routes suggests that only one member of a presumed pair is usually detected at any given time. Possible exceptions include some corvids, in which both members of a pair are highly vocal, and swifts and swallows, in which both males and females typically forage together over open habitats. A pair correction of 2 (double) may also be high for species with a high proportion of singing but unpaired males. The 'correct' pair correction for all species lies somewhere between

1 and 2 and may be determined empirically with further study.

Comparisons with Breeding Bird Atlas Estimates

Few independent population estimates exist with which to make even crude comparisons with our BBS-derived estimates for common landbirds. One source of such data is the simple order-of-magnitude estimates of breeding populations gathered during Breeding Bird Atlas work in Ontario (Cadman et al. 1987) and in the Maritime Provinces (Erskine 1992). During the course of atlassing in these areas, observers were asked to estimate the total breeding population of each species within 100-km^2 squares. Although these estimates are very crude (e.g., 1, 2-10, 11-100, 101-1,000, 1,001-10,000 or 10,001-100,000 pairs in a square), precision is gained from the very large number of squares sampled. Because atlassers are not restricted to roads, to early mornings, nor to a single peak of the breeding season, atlas data differ from BBS in having a reduced bias against off-road habitats, seasonal changes in breeding activity, and nocturnal species rarely detected on diurnal routes. Atlases also differ by covering larger proportions of the landscape, providing a larger sample size of population estimates, coverage for less common species, and allowing extrapolation based on knowledge of the habitat by the observer.
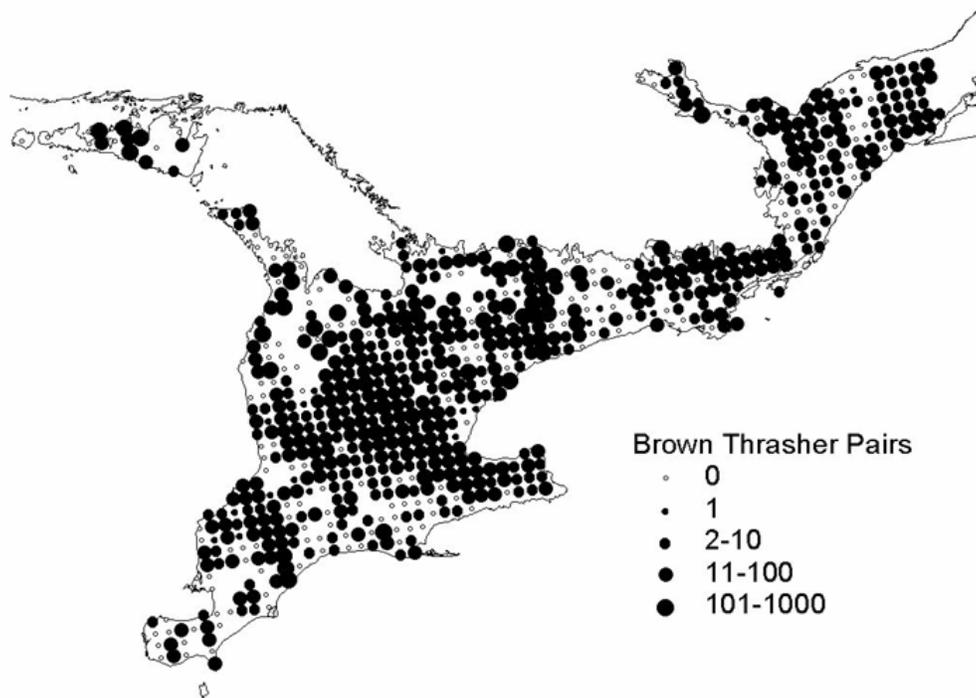

Figure 3— Brown Thrasher pair estimates in 10 x 10 km squares in the Ontario portion of BCR 13, from the Ontario Breeding Bird Atlas, 1981-1985.

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To estimate a population in an area covered by breeding bird atlas, we follow Erskine (1992) in taking the midpoint of each categorical range (assuming a Poisson distribution of abundances within each category) as the estimate for the atlas square. These estimates are totaled for each species across all squares in which estimates were made, then extrapolated to account for unsampled squares. This method is illustrated using data for the Brown Thrasher (*Toxostoma rufum*) in the Ontario portion of Lower Great Lakes-St. Lawrence Bird Conservation Region (BCR 13). Brown Thrashers were found in 549 out of 744 censused atlas squares within this region, and estimates within squares ranged across several abundance categories (*fig. 3*). Extrapolating abundance from Poisson midpoints of these categories, and extrapolating to the full 840 squares in the region, we derive a population estimate for the region of 42,369 pairs. We compared atlas-derived population estimates for landbirds present in 25 or more atlas squares with population estimates based on the 28 BBS routes run from 1981-1985 within the same region. We then replicated this comparison using BBS and atlas data from the Maritime Provinces (part of BCR 14), which involved 1682 atlas squares and 39 BBS routes conducted from 1986-1990. In the Maritime comparison, we used estimates from Erskine (1992) only for species where they were based on data from atlassers, disregarding estimates from other sources.

Comparisons with Breeding Bird Census

Another source of density estimates for landbirds is the Breeding Bird Census (BBC), in which observers estimate breeding populations in small plots of fixed area and uniform habitat. We used the Canadian Breeding Bird (Mapping) Census Database (Kennedy et al. 1999) to obtain landbird densities in BCRs 13 and 14 for comparison with our BBS estimates. Because BBC plots are not randomly distributed across the landscape, we use total landbird density as our basis of comparison, rather than density of individual species. We also calculated BBC landbird density within each broad habitat type, and adjusted regional BBC averages according to the proportion of the regional landscape in each habitat type, based on satellite land cover data.

Results
Population Estimates

First approximations of breeding populations were derived for 167 species that were sampled by the BBS in the Lower Great Lakes-St. Lawrence Plain (BCR 13) and for 154 species in the Atlantic Northern Forest (BCR 14). These estimates ranged from roughly 100 breeding individuals for rare breeders such as

Dickcissel (*Spiza americana*) and Le Conte's Sparrow (*Ammodramus leconteii*) in BCR 13, and for Peregrine Falcon (*Falco peregrinus*) in both regions, to 10 million American Robins (*Turdus migratorius*) in BCR 13 and 11 million Red-eyed Vireos (*Vireo olivaceus*) and 13 million robins in BCR 14. Breeding population size averaged 488,000 individuals across all landbird species in BCR 13 (398 birds per km^2), whereas populations averaged 792,000 individuals in BCR 14 (340 birds per km^2).

Of particular interest are population estimates for species considered of high conservation concern in these two regions. For BCR 13, we calculated populations for 20 species identified as high priorities by the landbird breakout group of the ongoing BCR 13 bird conservation initiative (see Hayes et al. this volume). Our estimates of regional populations for these species ranged from roughly 400 Short-eared Owls (*Asio flammeus*) to 1.9 million Bobolinks (*Table 2*). We also present average relative abundances on BBS routes in the region, as well as detection distance, effective sampling area, and time-of-day adjustment factors for each of these species. In BCR 14, our population estimates for 20 species with high PIF assessment scores (Panjabi et al. 2001) ranged from roughly 10,200 Whip-poor-wills to 2.1 million Veerys (*Catharus fuscescens*; *table 3*).

Comparison with Breeding Bird Atlas

We obtained independent estimates of breeding populations for 120 landbird species that had abundance data in at least 25 atlas squares and on at least one of 28 BBS routes in the Ontario portion of BCR 13. Correlation between these two sets of estimates was remarkably high (r = 0.95; *fig. 4a*). Two-thirds (66 percent) of species had estimates that differed by less than a factor of 2, and 99 percent were within an order of magnitude of each other. For example, in the Ontario/BCR 13 comparison, the atlas method estimated roughly 1.3 million pairs of American Robin versus 1.8 million pairs for the BBS method. Other close comparisons, representing a wide range of common and rare species, included European Starling (*Sturnus vulgaris*; 1.9 million vs. 2.2 million pairs), American Goldfinch (*Carduelis tristis*; 381,000 vs. 363,000), Hairy Woodpecker (*Picoides villosus*; 24,000 vs. 23,000), Great Horned Owl (5,700 vs. 6,300), and Henslow's Sparrow (*Ammodramus henslowii*; 147 vs. 160 pairs). Other individual comparisons that were not as close may suggest incorrect detectability thresholds, differences in habitat coverage between the two survey methods, or lack of precision for rare species.

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Table 2— *Population estimates and numerical objectives for landbird species identified as priority by Hayes et al. (this volume) in Lower Great Lakes-St. Lawrence Plain, BCR 13.*

Species	BBS avg/ route	Max. detection distance	BBS sample area (km²)	Time of day adjust	BCR population (individuals)	PT	BCR population objective	Numerical target (rounded)
Northern Harrier	0.302	400	25.1	1.29	6,200	3	1.1x pop	6,900
Black-billed Cuckoo	0.746	200	6.3	1.39	66,100	4	1.4 x pop	93,000
Short-eared Owl	0.004	200	6.3	1.60	400	5	2 x pop	800
Whip-poor-will	0.017	400	25.1	22.30	6,100	5	2 x pop	8,500
Red-headed Woodpecker	0.178	200	6.3	1.25	14,200	5	2 x pop	28,000
Eastern Wood-Pewee	3.477	200	6.3	1.12	249,200	4	1.4 x pop	350,000
Acadian Flycatcher	0.271	125	2.5	1.17	51,100	2	Current pop	51,000
Loggerhead Shrike	0.007	200	6.3	1.19	500	5	2 x pop	1,000
Sedge Wren	0.025	125	6.3	1.62	2,600	3	1.1 x pop	2,900
Wood Thrush	6.081	200	6.3	2.30	892,200	4	1.4 x pop	1,200,000
Brown Thrasher	1.499	200	6.3	1.12	107,800	5	2 x pop	215,000
Blue-winged Warbler	0.565	200	6.3	1.21	43,700	2	Current pop	44,000
Golden-winged Warbler	0.123	200	6.3	1.32	10,300	2	Current pop	10,000
Cerulean Warbler	0.100	125	2.5	1.35	21,800	2	Current pop	22,000
Hooded Warbler	0.357	200	2.5	1.20	68,800	2	Current pop	69,000
Field Sparrow	3.572	200	6.3	1.07	243,800	5	2 x pop	490,000
Henslow's Sparrow	0.025	200	6.3	1.66	2,700	5	2 x pop	5,600
Grasshopper Sparrow	0.476	200	6.3	1.47	44,700	5	2 x pop	89,000
Bobolink	24.863	200	6.3	1.21	1,927,000	4	1.4 x pop	2,700,000

Notes: Area of BCR13 is 201,292 km². Pair adjust = 2 for all species. For descriptions of detection distance categories, BBS effective sample areas for each species, pair adjustment, time-of-day adjustments and population trend (PT) scores, see Methods.

Table 3— *Population estimates and numerical objectives for landbird species with high PIF Assessment Scores in Atlantic Northern Forest, BCR 14.*

Species	BBS avg / route	Max. detection distance	BBS sample area (km²)	Time of day adjust	BCR population (individuals)	PT	BCR population objective	Numerical target (rounded)
Broad-winged Hawk	0.190	125	2.5	2.63	143,100	2	Current pop	140,000
Ruffed Grouse	0.218	80	1.0	1.37	214,700	5	2 x pop	430,000
Whip-poor-will	0.016	400	25.1	22.3	10,200	4	1.4 x pop	14,000
Yellow-bellied Sapsucker	3.351	125	2.5	1.40	1,342,700	4	1.4 x pop	1,880,000
Black-backed Woodpecker	0.043	125	2.5	1.81	22,300	3	1.1 x pop	25,000
Olive-sided Flycatcher	0.551	200	6.3	1.25	78,700	5	2 x pop	160,000
Veery	10.889	200	6.3	1.67	2,071,600	4	1.4 x pop	2,900,000
Wood Thrush	4.983	200	6.3	2.30	1,302,900	5	2 x pop	2,600,000
Chestnut-sided Warbler	7.622	200	6.3	1.23	1,070,000	4	1.4 x pop	1,500,000
Cape May Warbler	0.371	125	2.5	1.31	139,900	4	1.4 x pop	196,000
Black-throated Blue Warbler	1.988	125	2.5	1.12	639,400	2	Current pop	640,000
Blackburnian Warbler	2.324	125	2.5	1.28	852,700	1	Current pop	850,000
Bay-breasted Warbler	0.727	125	2.5	1.28	267,100	4	1.4 x pop	370,000
Canada Warbler	1.216	125	2.5	1.25	436,500	5	2 x pop	870,000
Scarlet Tanager	1.496	200	6.3	1.14	193,500	2	Current pop	190,000
Nelson's Sharp-tailed Sparrow	0.077	125	2.5	1.92	42,400	3	1.1 x pop	47,000
Rose-breasted Grosbeak	2.731	200	6.3	1.09	340,400	4	1.4 x pop	480,000
Bobolink	7.271	200	6.3	1.21	1,004,100	4	1.4 x pop	1,400,000
Rusty Blackbird	0.179	200	6.3	1.44	29,300	5	2 x pop	59,000

Notes: Area of BCR14 is 358,697 km². Pair adjust = 2 for all species. For descriptions of detection distance categories, BBS effective sample areas for each species, pair adjustment, time-of-day adjustments and population trend (PT) scores, see Methods.
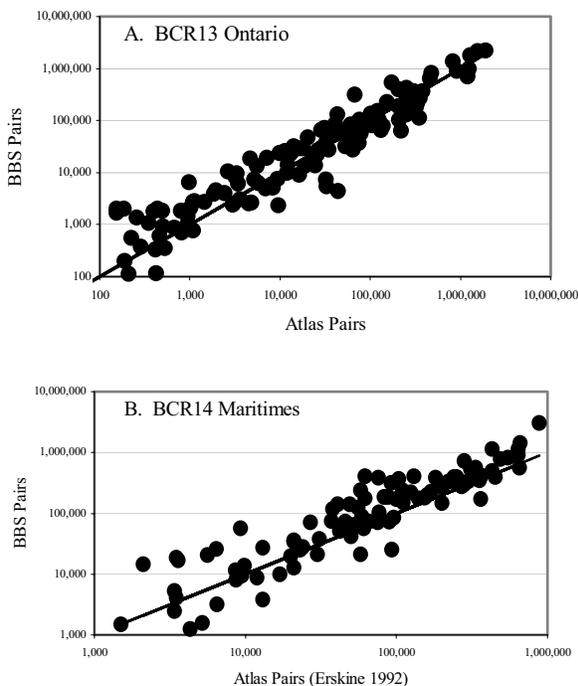
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Figure 4— Comparison of BBS- and Atlas-derived population estimates: A. Ontario portion of BCR 13, 1981-1985; B. Maritime provinces (BCR 14), 1986-1990. Line shows equal BBS and Atlas values. Landbirds with atlas estimates from 25+ atlas squares and found on one or more BBS routes are included.

A similar comparison in the Maritime Provinces portion of BCR 14 also resulted in a high correlation (r = 0.91) between atlas- and BBS-derived estimates for 99 species (*fig. 4b*). For this comparison, we relied on Erskine's (1992) calculated estimates, which involved removing the highest 3 percent of abundance estimates for each species, and reducing the midpoint of the top abundance category. We estimate that this trimming procedure reduced atlas population estimates by more than 50 percent, on average, and resulted in conservative (lower) populations relative to our BBS-derived estimates. Still, atlas and BBS estimates were within a factor of 2 for 64 percent of species, and were within an order of magnitude for all species.

Comparison with Breeding Bird Census

Total population density for all landbird species was approximately three times higher when based on Breeding Bird Censuses, compared with BBS-derived density estimates, in both BCRs (*table 4*). Even when BBC densities were corrected for habitat availability in each BCR, BBC densities remained high relative to BBS-derived densities.

Deriving Numerical Population Objectives

To derive numerical population objectives in *tables 2* and *3*, we start with the premise that a reasonable conservation target is to reverse population declines observed over the past 30 to 40 years, as measured by BBS or equivalent survey. Rather than extrapolate annual rates of decline over 30 to 40 years, we chose to use broad classes of population decline as the basis for objectives, as in Rich et al. (2004). For this purpose we used population trend scores (PT) assigned to species in the PIF species assessment process (Carter et al. 2000, Panjabi et al. 2001). These scores of 1-5 are based on BBS population trends (or equivalent) over the entire timeframe of the survey, usually since 1966. A PT of '5' is assigned to species that have declined significantly by at least 50 percent over a 30-year period. For these species, our conservation objective is to double current populations over some future time period, and the numerical target is calculated as roughly twice the current population estimate. A PT score of '4' is assigned to species with less certain declines or significant declines of between 15 and 50 percent over 30 years. For these species we propose an objective of restoring populations based on a 30 percent decline (approximately the midpoint of the 15-50 percent range), which translates to a numerical target of about 1.4 times current population. PT scores of '3' are assigned to species with highly variable, uncertain, or unknown population trends. For these, we suggest a conservative objective of maintaining slightly higher populations in the future until we can acquire sufficient trend data to measure trend; i.e., 1.1 times current population estimates. Finally, for species with stable (PT = 2) or increasing (PT = 1) populations, our conservation objective is to maintain future populations at or above current levels.

Table 4— *Comparison of total landbird density from Breeding Bird Census (BBC) plots vs. estimates based on Breeding Bird Survey (BBS), for BCRs 13 and 14.*

BCR	BBC plots (N)	BBC landbird density (prs/km^2)	BBC density weighted by habitat in BCR (prs/km^2)	BBS landbird density (prs/km^2)	Ratio BBC/BBS
BCR 13	204	592	506	198	2.6
BCR 14	93	632	621	210	3.0

Note: Estimates are for Canadian portions of the BCRs.

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Note that this categorical assignment of numerical objectives reduces the reliance on specific BBS trend estimates, which often have wide 95 percent confidence limits, especially in regions with small samples of BBS routes. Using this approach, we present conservation objectives and numerical population targets for several species identified as priorities in BCR 13 (*table 2*) and BCR 14 (*table 3*).

Discussion

We believe that our pragmatic approach, with clearly stated assumptions, can produce useful first approximations of total population size for North American landbirds. Our comparisons with independently derived population estimates suggest that extrapolations from BBS abundance data typically yield estimates well within the correct order of magnitude.

It is likely that our population estimates are conservative for most species because we did not include any correction for birds within maximum detection distance but still not detected during a 3-minute BBS count even at peak detection time of day, e.g., because they didn't vocalize or because observers missed them. Bart (in press) estimated that 30 to 70 percent of shrub-steppe birds do not call during a 3-minute count, and a further 20 to 30 percent of birds singing within detection distance are missed by BBS observers. Our comparisons to BBC landbird densities also suggest our BBS-derived estimates are conservative, perhaps by a factor of 3, though it is possible that BBC densities are high if plots were biased to sites with more birds or if densities were overestimated in small BBC plots.

A habitat bias on BBS routes, if present in the region under consideration, would result in under- or over-estimated populations, so is best measured and incorporated into the estimate (Bart, in press). However, even where habitat bias has not been measured, this does not rule out use of BBS-derived estimates to set and track conservation targets, as long as progress towards objectives is measured using the same method. The same studies that documented a bias against forest sampling on roadside routes (Bart et al. 1995, Keller and Scallan 1999) did not find an equivalent bias in terms of the change in land cover over time.

While we are encouraged by the comparisons with other measures of population size, we acknowledge that our estimates are only crude first approximations that might be poor for some groups of birds, or in regions where BBS routes are sparse or strongly habitat-biased. We therefore encourage further research to refine the corrections we have applied so far and to test for and correct any habitat bias in BBS surveys in specific regions. Studies of species-specific detection distances, vocalization frequency, detection probabilities of males and females, and proportion of unpaired birds detected would all be extremely useful for

refining population estimates. Our efforts thus far have focused on landbird species, which as a group are reasonably well sampled by BBS. These methods may also be appropriate for some species of waterfowl, shorebirds, and waterbirds typical of landscapes sampled by BBS; testing is needed to confirm this. Finally, our method does not address vast boreal/taiga and arctic regions of North America that are not sampled by BBS. Other methods will be needed to estimate populations of these far-northern breeding species (Rich et al. 2004, Appendix B). We invite additional comparisons and discussion, and we encourage testing of these methods on other species and in other regions.

Even if we accept the first approximation of landbird population estimates as reasonable, using these to set numerical conservation targets remains controversial. Fear exists among academic ornithologists and conservation practitioners that using inaccurate population estimates to set conservation targets may lead to misdirected conservation actions and loss of scientific credibility. Alternative forms of population objectives have been proposed and discussed, including using minimum block sizes of habitats for maintaining 'source' or 'viable' populations, using BBS relative abundance as a surrogate for population size (e.g., achieve a regional density of x birds per BBS route), and using raw trend estimates as objectives (e.g., stabilizing a 2 percent per year BBS decline). Our assumption in using explicit population estimates is that there is compelling value in knowing the magnitude of population change desired and in having easily understood objectives. Population estimates also allow comparisons to independently estimated sources of mortality and a grasp of the magnitude of habitat required to sustain bird populations across the landscape.

Other considerations in setting conservation targets relate to timeframes, historic baselines, and political and social acceptability of objectives. We selected 'early BBS' as a reasonable historic reference because it represents the extent of our knowledge of population trends for most species, and because it is a similar timeframe to that proposed for the restoration of waterfowl and shorebird populations. Just as important, it also allows a comparable measurement of success into the future, using the same BBS methodology. Numerous factors could make it desirable to alter this timeframe, however. For example, some populations and habitats were severely altered long before the beginning of the BBS, and it may be desirable to attempt restoration of these to some earlier baseline. Alternatively, some populations or habitats may have been artificially abundant in the 1960s (relative to pre-settlement conditions), such as some early successional habitats in eastern regions, or populations responding to spruce-budworm outbreaks, and proposing the return to these levels may be inappropriate. Full discussion of these and other factors is critical for setting effective and achievable conservation targets, but such a discussion is beyond the scope of our paper. Our proposed

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method for setting numerical targets can be adapted to a variety of baselines or timeframes.

In conclusion, we believe that numerical population estimates and conservation targets for landbird species are useful and achievable. We propose a simple methodology for extrapolating from widely available BBS abundance data, while stating a series of assumptions and acknowledging the limitations of this approach. We encourage further research that aims to refine population estimates and better enables us to understand and use data from the BBS. We further encourage the use of additional survey data, point counts, checklist counts, and other measures of abundance to fill in gaps for species and regions poorly covered by BBS. Finally we encourage the use of population-based conservation targets in continental and regional plans as a compelling means of justifying and communicating levels of desired population and habitat change in specific regions.

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